

	1 of 18	Technical Work Instruction – Casing/Pilot Milling				OEPS
DOCUMENT NUMBER	CLASSIFICATION	DOCUMENT LEVEL	REVISION NUMBER	ISSUE DATE	PREPARED BY	APPROVAL
GL-INTS-OEPS-L4-716	CONTROLLED	L4	A	26 Oct 2020	Bobby Jarrett	TWI COMMITTEE

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1.0 Purpose

This document discusses standard procedures to be used while Pilot Milling during Fishing Operations to remove the casing from the wellbore.

2.0 Scope

This procedure applies to the Weatherford Supervisor on location, the Operations Manager in the Branch Plant location and also the Technical Sales team as a reference to assist in selecting the proper milling BHA and plan in proper operation in the field. This document includes the steps make-up, trip in the hole and cleaning the hole along with removal of debris (swarf).

3.0 Pre-Planning

3.1 Milling Considerations

Before embarking on a prolonged milling job, there are several issues, which must be considered. These considerations can mean the difference between a project being completed on time and budget or project running into significant difficulties and costing much more than anticipated. With proper preplanning, the probability of performing a good effective job will be greatly increased.

It is important to consider the following before beginning a job: (1) Casing eccentricity, (2) Cutting removal, and (3) Pilot mill design.

3.2 Casing Eccentricity

An important aspect of planning a milling job is to determine the degree of eccentricity between the casing strings. This is an important consideration and is used to determine the proper stabilization below the pilot mill. If the inner casing to be milled is held in place with cement and was run with casing centralizers installed, the casing strings will most likely be concentric with one another. In this condition, the stabilizer OD of the pilot assembly should be the drift ID of the inner casing string being milled. This will ensure that the mill runs true to the centerline of the inner casing. It will also ensure that the couplings are milled completely and that mill life is preserved. If the couplings are not completely milled, problems can be encountered when the skinned coupling is circulated to the surface. This often results in a plugged flow line.

Should the casing not have centralizers installed and some hole angle exists, it is safe to assume that the casing strings are eccentric.

In any particular case, logs may indicate that the casing strings are touching for a great deal of their length and this would be verified by calculation (casing eccentricity calculations).

This requires a different strategy. A reduced OD stabilizer will be required below the mill to allow it to walk away from the ID of the casing being milled. This will prevent the mill from milling into the primary string of casing. This is important because it is usually required that the primary string of casing still be testable after milling is complete. This is particularly important on wells where the hole angle is great enough that a large side load may be placed on the mill. A properly designed mill with gauge protection on the OD of the blades will also help protect from milling the primary string of casing.

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3.3 Cuttings Removal

Removal of cuttings during milling has a great impact on the success of a milling job. If cuttings are not removed quickly and efficiently then downtime due to bird-nesting can become a problem. Bird-nesting occurs whenever a large number of cuttings accumulate in an area in the annulus. Surface equipment, flow line configuration, and milling fluids all become important for proper cutting removal.

3.4 Surface Equipment

A typical arrangement of flow equipment required to remove cuttings efficiently at the surface is as follows. Flow is routed from the bell nipple through open flow ditches to two shale shakers (or capable swarf handling unit). The fluid then exits the shale shaker into the sand trap/settling pit, then to the suction pit. Large ditch magnets are strategically placed in the flow line and suction intakes. The magnets should be cleaned by rig personnel every half hour to remove settled swarf. See Basic Circulating System Pilot/Casing Milling, Page 19.

3.5 Flowline Configuration

To avoid flip-out of swarf in the bell nipple and BOP riser and the subsequent bird-nesting and pack-offs, it is necessary to minimize the size of the BOP and bell nipple riser. This will allow a higher annular velocity to keep the BOP and BOP riser clear of swarf. The flow lines from the riser to the shale shakers or swarf management unit must be as large and straight as possible with all valves removed. There should not be any obstructions in the flow lines to allow a bird-nest to form.

3.6 Milling Fluids

Mud properties: Water base is the best using an XCD polymer with a 55–65 YP and a 65 -75 funnel viscosity. If OBM must be used a YP of 40+ is necessary along with a funnel viscosity of 70-90. Salt saturated mud is also an option as it is easy to get the required high YP, however, it must carry a high SG/PPG.

3.7 Drilling Jars/ Shock Tools

Drilling jars should be run with all assemblies. In the preplanning phase, a Jar Placement analysis should be run to optimize the jarring impact if needed.

The Weatherford O.S.T. Shock Tool is the recommended shock tool to be run. The tool needs to be specified to be dressed using the "Soft Spring" package. This will optimize the shock to be able to perform as needed while milling with lower milling rates. A properly balanced shock tool is essential in helping to extend mill life.

3.8 Stabilization

Stabilization is critical when milling casing inside another string of primary casing. Stabilizers to be Integral Blade type with Hard Facing on the OD surface along with a cutting structure of either carbide or inserts on the end of the blade along the transition face from Full OD to just before the body. This will give the ability if pulling up into bird-nesting to be able to cut relief from swarf.

Stabilizer OD to be the same OD as Pilot Mill. This allows the pilot mill to mill complete OD as dressed along with having the stabilizer it keeps from letting the blades dig into the ID of the primary string of casing.

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In the event of the pilot mill losing gauge, the stabilizer will also act as a stop. This will keep from skinning a long section of casing.

The stabilizer above the shock tool will also be the same OD as the stabilizer above the Pilot Mill.

3.9 Pilot Mill Design

The pilot mill design is extremely important to the completion of a successful milling operation. Insert technology advances have allowed the creation of an advanced cutting structure that effectively manages the cutting size regardless of the operating parameters. Inserts allow a much more aggressive cutter that will function effectively at high ROP. Also, the use of thicker inserts and improved carbide grades allow longer on-bottom time because of improved wear capability. The addition of gauge protection on the OD portion of the blades give the mill added life and maintaining gauge more consistently.

The preplanning considerations discussed thus far should be reviewed for every milling job. Milling casing with Weatherford's pilot milling technology will prove to be a particularly cost effective solution.

4.0 Abbreviations

- **OEM** Original Equipment Manufacturer
- **TU** Tech Unit
- **XCD** Xanthum Gum (XCD Polymer)
- **OBM** Oil Base Mud
- **SOP** Standard Operating Procedure
- **PPE** Personal Protective Equipment
- **BHA** Bottom Hole Assembly
- **ID** Inside Diameter
- **OD** Outside Diameter
- **IB** Integral Blade
- **RIH** Run in Hole
- **POOH** Pull Out of Hole
- **ROP** Rate of Penetration
- **WOM** Weight On Mill
- **AV** Annular Velocity
- **TD** Total Depth
- **YP** Yield Point
- **SG** Specific Gravity
- **GPM** Gallons per Minute

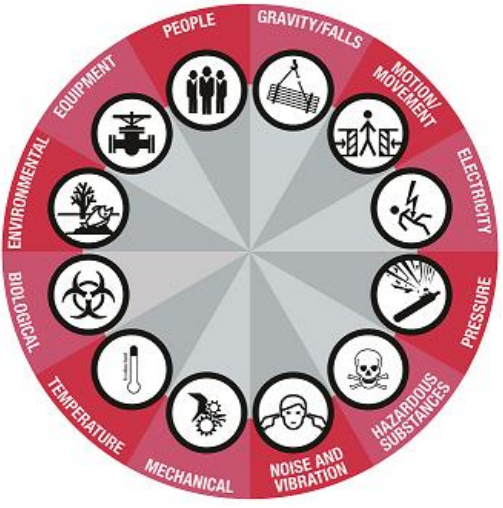
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5.0 Safety

5.1 Statement of Compliance

- 5.1.1 Locations shall conduct a site specific workplace risk assessment to determine potential hazards which necessitate the implementation of controls including personal protective equipment (PPE). Attend all appropriate safety briefings / meetings.
- 5.1.2 Employees and sub-contractors regardless of position or qualification not only have the right but the obligation to stop any work if conditions are deemed to be unsafe or a hazardous situation arises
- 5.1.3 In the event of any conflict with this technical unit the OEM documentation takes precedence and its requirements are, inclusive of specified OEM spare parts
- 5.1.4 The Management of Change GL-WFT-OEPS-L2-15 Management of Change applies to this work instruction, modification is prohibited without authorization from the GPLM

5.2 Hazard Identification

Symbols & Symbol Guidance	
	Gravity / Falls
	The force caused by attraction of all other masses to the mass of the earth. Examples: falling object, collapsing roof, and a body tripping or falling
	Motion / Movement
	The change in position of objects or substances. Examples: vehicle, vessel, or equipment movement; flowing water; wind; and body positioning when lifting, straining or bending
	Electricity
	The presence and flow of an electric charge. Examples: Power lines, transformers, static charges, lightning, energized equipment, wiring, batteries
	Pressure
	Energy applied by a liquid or gas that has been compressed or is under a vacuum. Examples: pressure piping, compressed cylinders, control lines, vessels, tanks, hoses, and pneumatic and hydraulic equipment
	Hazardous Substances
	Including chemicals, radioactives, lithium batteries, explosives – The energy present in chemicals that inherently, or through reaction, has the potential to create a physical or health hazard to people, equipment or the environment. Examples: flammable vapors, reactive hazards, carcinogens or other toxic compounds, corrosives, pyrophorics, combustibles, oxygen-deficient atmospheres, welding fumes and dusts
Hazard identification should be a systematic process and the wheel is used to ensure that the person(s) conducting the exercise have considered all categories and thus ensuring that the assessment is comprehensive. Each of the categories is considered in turn and hazards related the task/activity can be identified	Noise & Vibration
	Sound is produced when a force causes an object or substance to vibrate and the energy is transferred through the substance in waves. Examples: equipment noise, impact noise, vibration, high-pressure release, and the impact of noise to communication
	Mechanical
	The energy of the components of a mechanical system, i.e., rotation, vibration, or motion within an otherwise stationary piece of equipment or machinery. Examples: rotating equipment, compressed springs, drive belts, conveyors, and motors.
	Temperature
	The measurement of differences in thermal energy of objects or the environment, which the human body senses as either heat or cold. Examples: open flame, ignition sources, hot or cold surfaces, liquids or gases; steam; friction
	Biological
	Living organisms that can present a hazard. Examples: animals, bacteria, viruses, insects, blood-borne pathogens, improperly handled food, and contaminated water
	Environmental
	The impact of our surroundings. Examples: weather conditions, simultaneous operations, confined spaces
	Equipment
	Critical to Service Quality. Examples: critical installation, hold / witness point, special equipment, parameters, specifications
	People
	Specialized or additional training requirements over and above normal role based requirements.

5.3 Personal Protection Requirements

Unless a risk assessment determines the need for additional specialized PPE, the following approved equipment is required; steel toed footwear, safety glasses / eye wear, hard hat / helmet, gloves suitable for the task, coveralls and hearing protection.

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6.0 Procedure

6.1 Pre-Running Checks

1. Verify Casing OD and ID to be milled and ID of Primary Casing or Open Hole size.
2. Has USIT or CBL been ran to verify top of cement and or bond?
3. Are centralizers in Section being milled?
4. If milling in open hole what is formation.
5. Is a deviation survey available?
6. Has Casing Eccentricity calculations been prepared and if required are mills available?
7. All are mills dressed according to prepared program and prints, inspected and OD verified with ring Gauges according to WT-552, current revision?
8. Has Jar Placement Analysis been run and reviewed to meet BHA recommendations?
9. Check Shock Tool, verify if fit for purpose and dressed with “Soft spring” package for milling.
10. Are back-ups provided for all essential components? Mills, Impact Tools, Crossovers, Contingency Fishing Tools...etc.?
11. Provide gauge rings for rig use to gauge mill wear for all mills.

6.2 Running of Assemblies

Symbol	Work Steps	Hazards	Basic Controls
	Unloading equipment from delivery truck / standby box	Lifting device, line of fire, equipment slippage / dropping, potential pinch points when handling of Tool and Accessories	Toolbox talk: handling / lifting of equipment Proper slinging and handling techniques Keep personnel out of the line of fire of the lifting device and load
	Assembly on Rig Floor, Handling and Assembly of BHAs	Manual handling of Components and Assembly by Hand	Toolbox Talk: Appropriate use of winches, slings and had placement for handling Large Mills, Stabilizers and Impact Tools
	Tripping in / Out of Hole	Hang-up in BOP's/Liner Tops	Slow & Careful through BOP's and restricted IDs Controlled speed tripping out Watch for signs of bird-nesting at any liner tops or ID change in Hole or BOP Cavity/ Riser
	Make Up/Breakdown of BHA Assembly	Use of Manual Tong or Mechanized Torque equipment Torque Values Pipe or Tools Sliding in slips or tong slippage Sharp shards from tongs Swarf on connections also shock tool and jars	Ensure all are Trained on Equipment and manual handling As per OEM/API Specifications All Tong and Slip Dies are inspection and in good condition When Sharp Shards are found ensure proper hand placement When Swarf is present ensure proper hand placement

1. Conduct JSA before handling of the Mills and Accessories and let everyone know the dangers of handling equipment. Explain all the pinch points to them.
2. Measure each Tool and record the OD's / ID's /Lengths. Verify connections.
3. Pickup and make up the Milling Assembly as follows:

- a) Taper Mill
- b) Bit Sub W/Float

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- c) 2 ea. DP (Specifically for open-hole use. Omit if casing is to be milled inside casing)
- d) IB Stabilizer (To Drift of Casing being Milled, may be undersized if casing is eccentric).
- e) Weatherford Pilot Mill (OD to be 1/8" to the side larger than OD of casing being milled).
- f) IB Stabilizer (Same OD as Pilot Mill. With Gauge Protection and Cutting Structure on end of blades).
- g) Shock Tool (Set up for Milling if Spring Type)
- h) IB Stabilizer (Same OD as Pilot Mill. With Gauge Protection and Cutting Structure on end of blades).
- i) 9 ea. Drill Collars
- j) Drilling Jars (Run Jar Analysis to verify placement)
- k) 2 ea. Drill Collars
- l) Crossover
- m) Drill Pipe to Surface

Notes

- All connections below the Pilot Mill to be made up dry to API+10%
- A multi-cycle circulating sub may be ran in Drill Pipe string to aid in cleaning due to lower AV.

4. RIH w/ BHA to 1 joint or 10m above the casing stump (taper mill depth) and take parameters. (With and without pumps).
5. Displace the well with suitable milling fluid. Target YP to be >55 (do not initiate milling until well has been displaced).
6. Continue to S/O and tag the top of the casing. (MARK THE PIPE AT THIS POINT).
7. P/U 5'/1.5m, turn the pumps on and commence rotating staging up noting torque. GPM required to maintain minimum annular velocity around drill pipe of 120 ft/per min and 120-200 RPMs).
8. Slack off and begin milling. (WOM 5-20,000) ROP Average 15-25 ft/hr). ROP may also be determined by how well cuttings are being removed from the annulus. Monitor flow and stand pipe pressure for signs of packing off.
9. Continue to mill down to desired depth.
10. Should the milling rates fall below an acceptable level of ROP, it may be necessary to POOH and change mill out. If high torque is causing drop in ROP, check eccentricity calculations as OD reduction may be required in lower stabilizer and taper mill.
11. Stop rotating, pick up and circulate hole clean.
12. POOH and proceed with Hole Clean-Up Operations (if required).
13. If a Hole Clean-up Trip is required pick up and make up the below Assembly:

- a) Bladed Junk Mill (OD to Primary Casing Drift or Hole size)
- b) Bit Sub w/Float
- c) IB Stabilizer (OD to Primary Casing Drift or Hole size)
- d) Pony Collar
- e) IB Stabilizer (OD to Primary Casing Drift or Hole size)
- f) 9 ea. Drill Collars
- g) Drilling Jars (Run Jar Analysis to verify placement)
- h) 2 ea. Drill Collars
- i) Crossover
- j) Drill Pipe to Surface

Notes

- A multi-cycle circulating sub may be ran in Drill Pipe string to aid in cleaning due to lower AV.

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14. RIH to initial start point of milling the casing
15. Pick Up 3', turn on pumps and begin rotating. GPM required to maintain minimum annular velocity around drill pipe of 120 ft/per min and 120-200 RPMs).
16. Slack off and commence reaming.
17. Continue to ream down to the top of the milled casing stub and mill away any potential damaged section. This may be required if pilot milling is not complete.
18. Stop Rotating, pick up and circulate hole clean.
19. POOH
20. At this point if Hole Cleaning run was required before Milling TD was reached then repeat steps 1-12. If not, then **Job Complete**.
21. If milling from just below surface is required, pick up the below Milling Assembly:
 - a) Taper Mill
 - b) Bit Sub W/Float
 - c) 3 ea. Drill Collars
 - d) IB Stabilizer (To Drift of Casing being Milled, may be undersized if casing is eccentric).
 - e) Weatherford Pilot Mill (OD to be 1/8" to the side larger than OD of casing being milled).
 - f) IB Stabilizer (Same OD as Pilot Mill. With Gauge Protection and Cutting Structure on end of blades).
 - g) Shock Tool (Set up for Milling if Spring Type)
 - h) IB Stabilizer (Same OD as Pilot Mill. With Gauge Protection and Cutting Structure on end of blades).
 - i) 9 ea. Drill Collars
 - j) Drilling Jars (Run Jar Analysis to verify placement)
 - k) 2 ea. Drill Collars
 - l) Crossover
 - m) Drill Pipe to Surface
1. Notes
 - All connections below Pilot Mill due to larger mass (Drill Collars) to be made up dry to API+15%.
22. Pickup BHA components as needed to tag top of casing with pilot mill. Make up Top Drive to single BHA component and make up to connection in rotary.
23. Pick up and displace the well with suitable milling fluid. Target YP to be >50 (do not initiate milling until well has been displaced).
24. Once displaced S/O and tag top of casing. (MARK THE PIPE AT THIS POINT).
25. P/U 5'/1.5m, turn pumps on and commence rotating staging up noting torque. GPM required to maintain minimum annular velocity around drill pipe of 120 ft/per min and 100-160 RPMs). If hi vibration occurs RPMs will need to be adjusted to accommodate.
26. Slack off and begin milling. (WOM 5-20,000) ROP Average 15-25 ft/hr). If hi vibration occurs lower WOM may be required, ROP may also be determined by how well cuttings are being removed from the annulus. Monitor flow and stand pipe pressure for signs of packing off.
27. Continue milling as needed adding each BHA component until reaching approximately 200'+ of casing milled.
28. At this point circulate well clean and POOH.
29. Remove Drill collars from below pilot mill and replace with standard lower assembly as outlined in Step 3.
30. RIH with Standard Pilot Milling BHA and begin milling, milling to depth required.

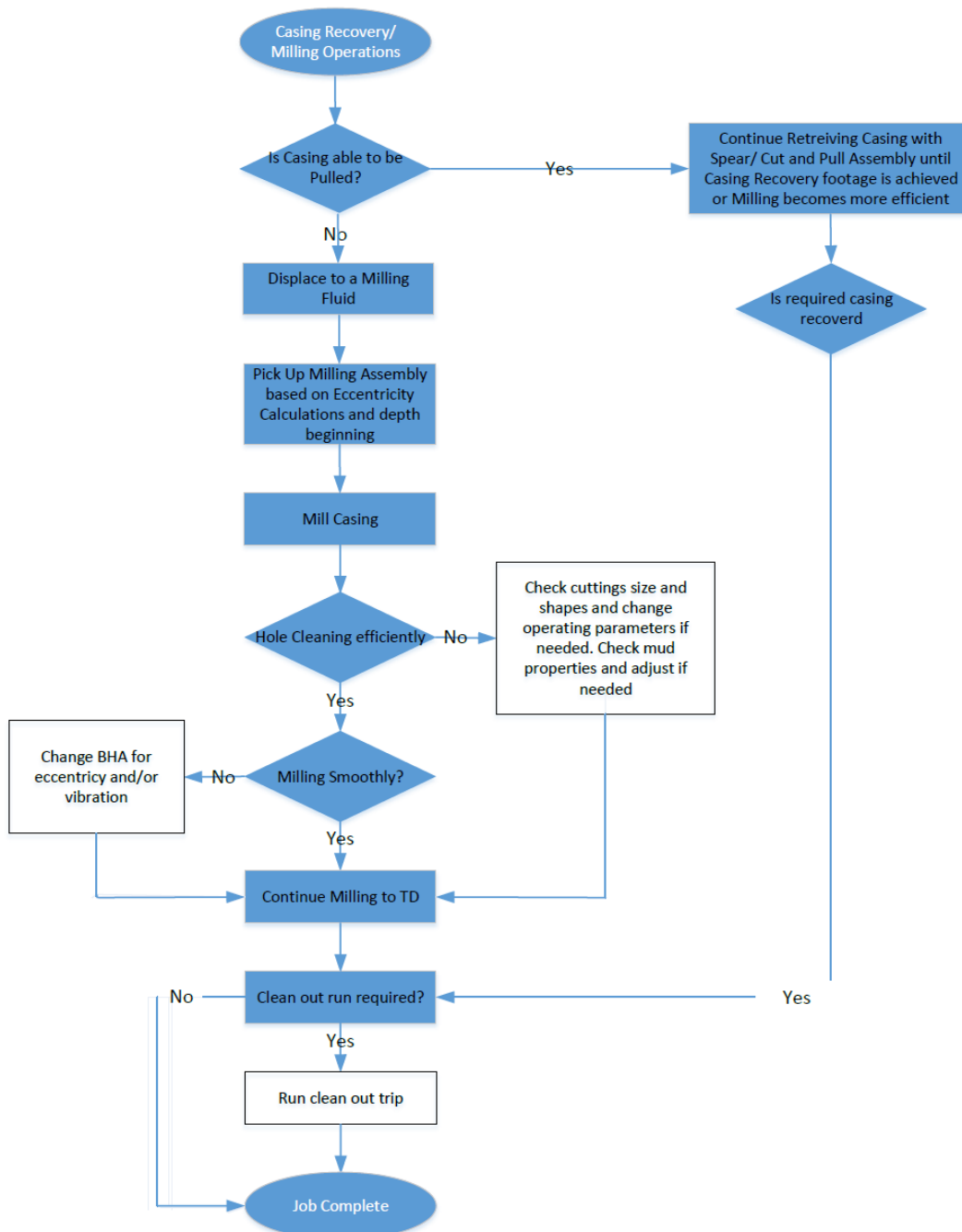
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7.0 Training

This equipment is covered by the Competency Assurance Program, only trained and competent personnel, or those under supervision of such persons, are authorized to undertake this task

8.0 Pilot/Casing Milling Decision Tree, Risk Analysis and Summary

8.1 Decision Tree



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8.2 Risk Analysis

PROBLEM	PROBABILITY	CAUSE(s)	CONTINGENCY
Stuck BHA/Work String	10%	Bird nesting of metal swarf in annulus	Use drilling jars to free BHA. Slow ROP and increase flow rate. Check fluid properties
Clogging/ plugging of flowline	25%	Excessive volume of metal swarf	Increase jetting of flow line. Reduce ROP. Straighten flow line. Check fluid properties.
Slow ROP	10% 5% 10%	Improper BHA design Un-cemented casing High torque and drag.	Change BHA design. Run CBL prior to job. Squeeze casing to be milled prior to job. Eccentrically milled casing collars stacked on mill body. Check mill OD's & lower stabilization. Clean out run w/ full gauge junk mill + stab.

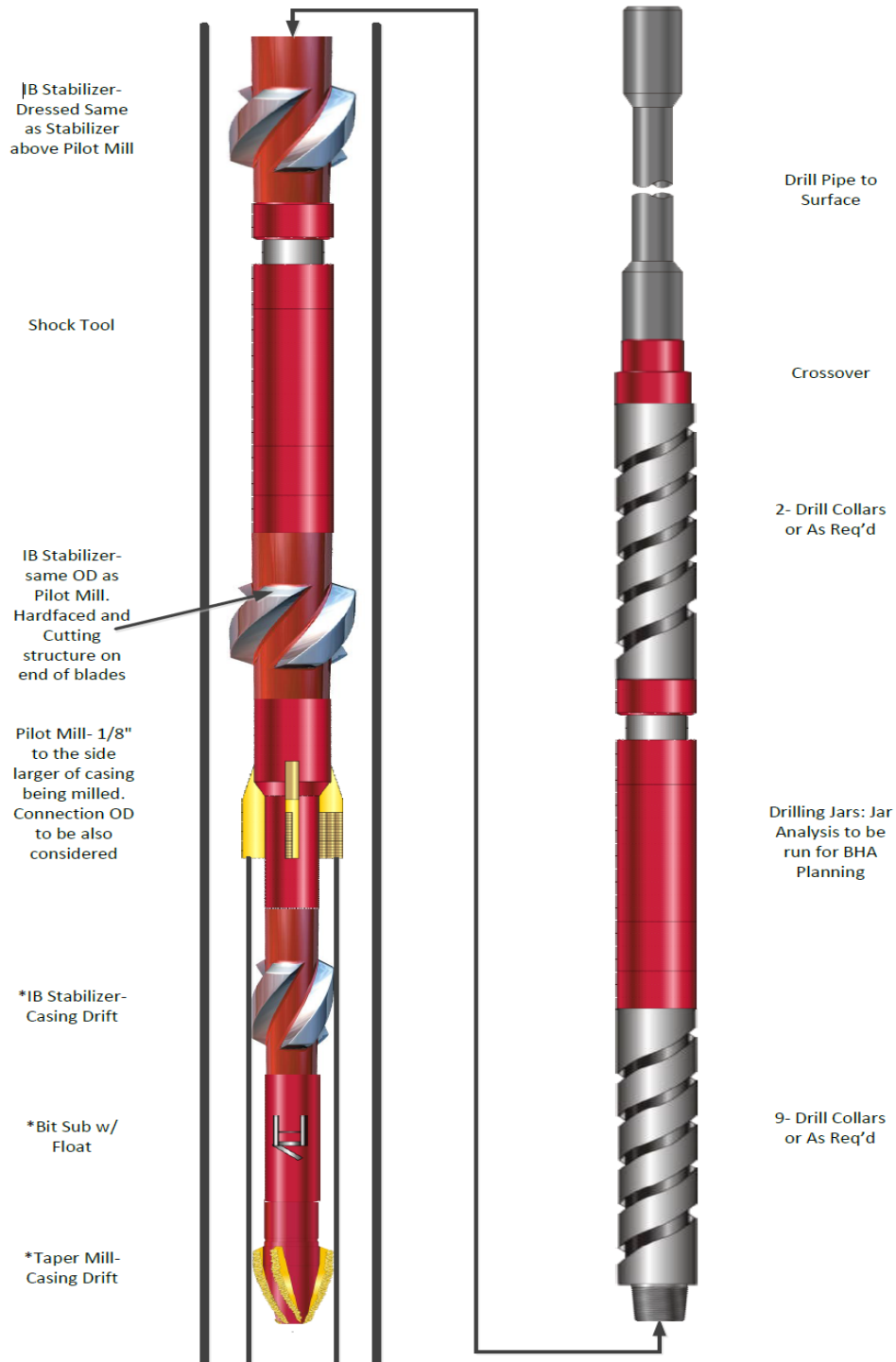
8.3 Summary

Pilot milling is highly successful if all requirements are planned for prior to beginning the job. Most major problems occur as a result of not being able to remove cuttings due to insufficient mud properties, bent or curved flow line, excessive ROP and dog leg severity. It must be noted that even if the well is vertical, the casing maybe eccentric in various areas of the milling path.

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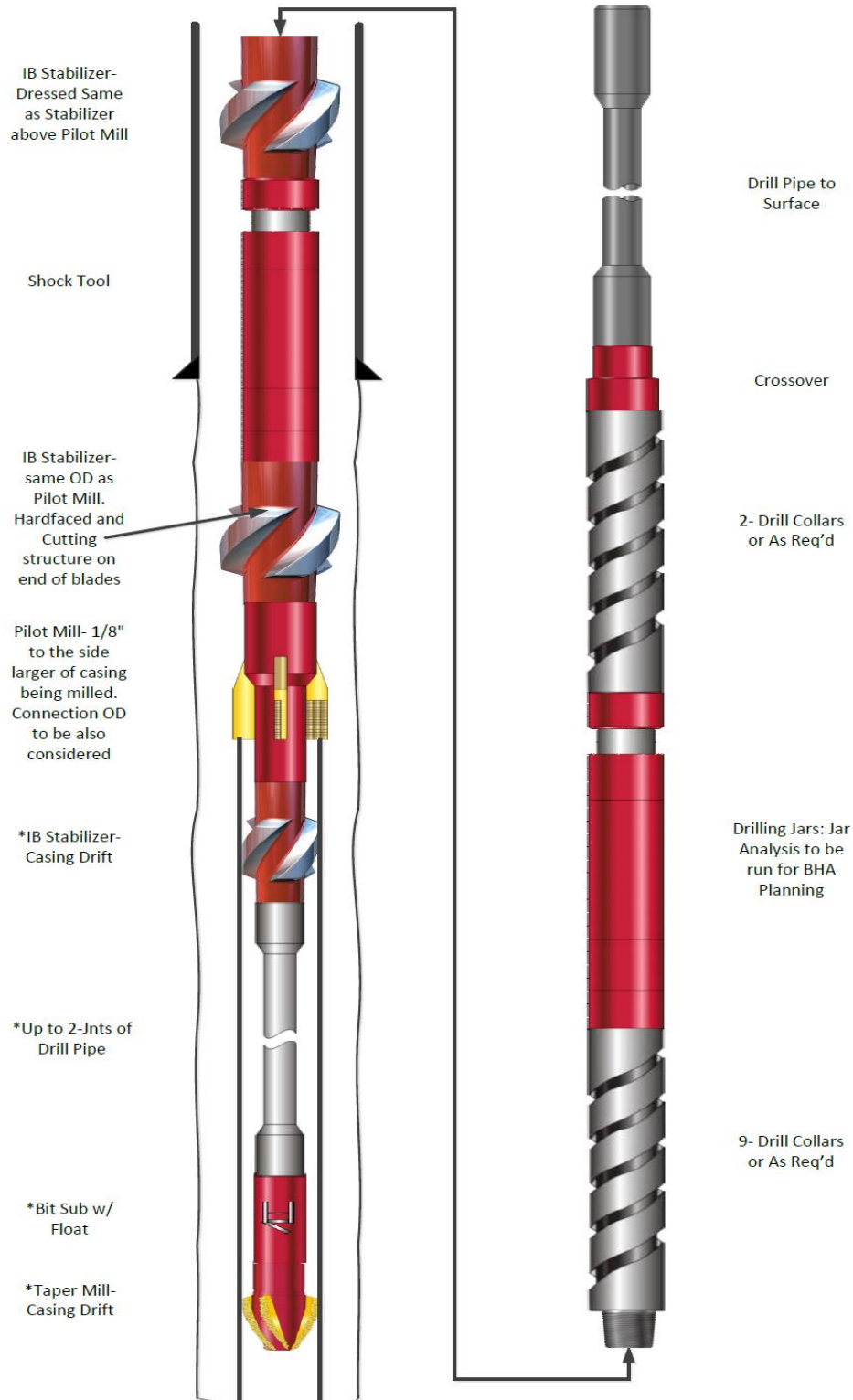
9.0 Example BHAs

9.1 Pilot Milling, Standard- Items noted with *, to be made up dry and torqued API + 10%



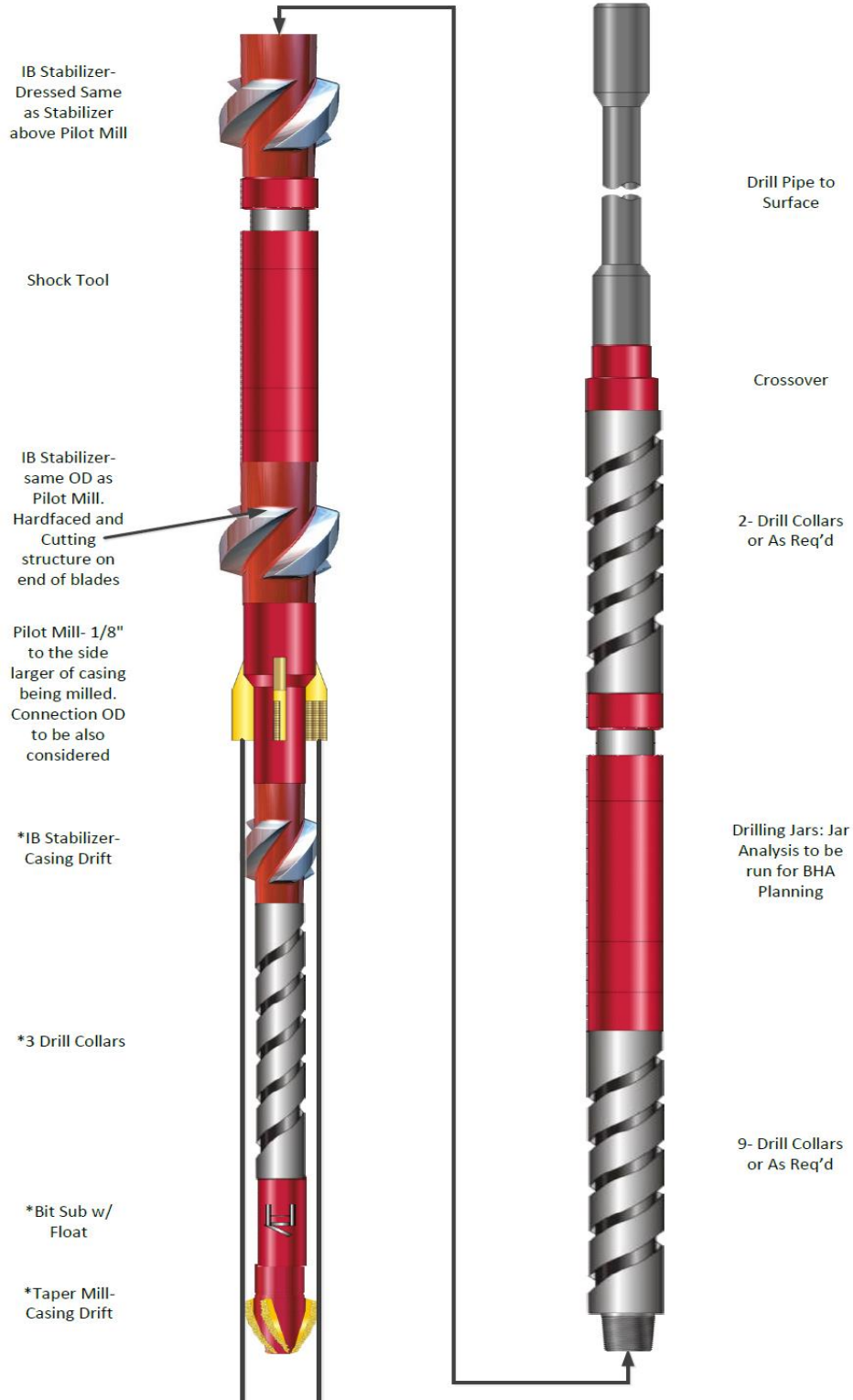
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9.2 Pilot Milling, Open Hole- Items noted with *, to be made up dry and torqued API + 10%



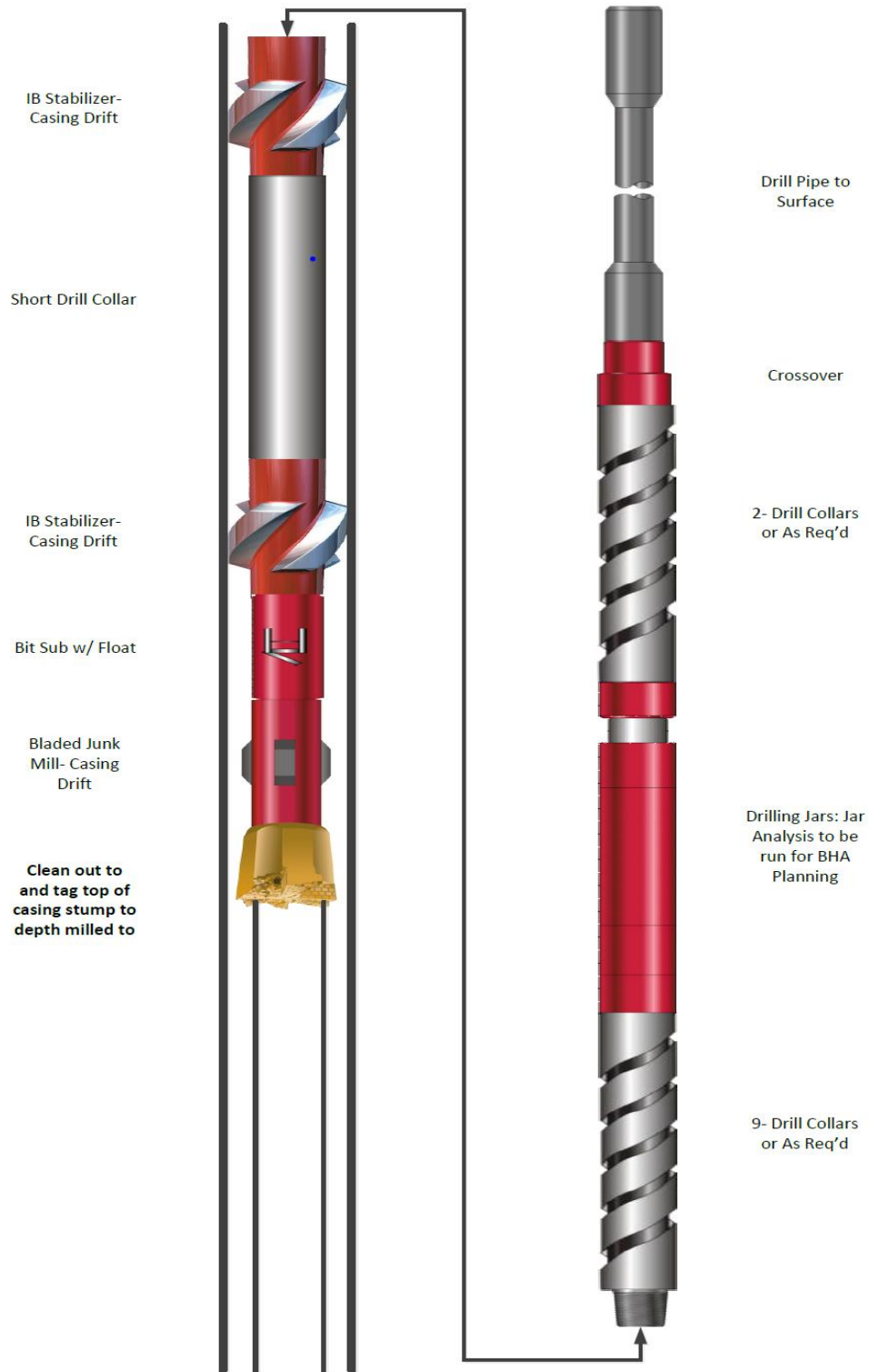
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9.3 Pilot Milling, Surface- Items noted with *, to be made up dry and torqued API +15%



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9.4 Clean Out Run



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10.0 Swarf Management

10.1 Ditch Magnets



Ditch Magnets should be placed in strategic areas of the flowline if open top. If a Swarf Management Unit is in place they should be placed downstream in the possum belly of the shale shaker and troughs of sand trap and/or settling pits. If the suction pit design will allow them to be placed near pump suction they will help mitigate any finer swarf cuttings from the pump expendables and also being re-circulated.

10.2 Swarf Removal System (SRS)

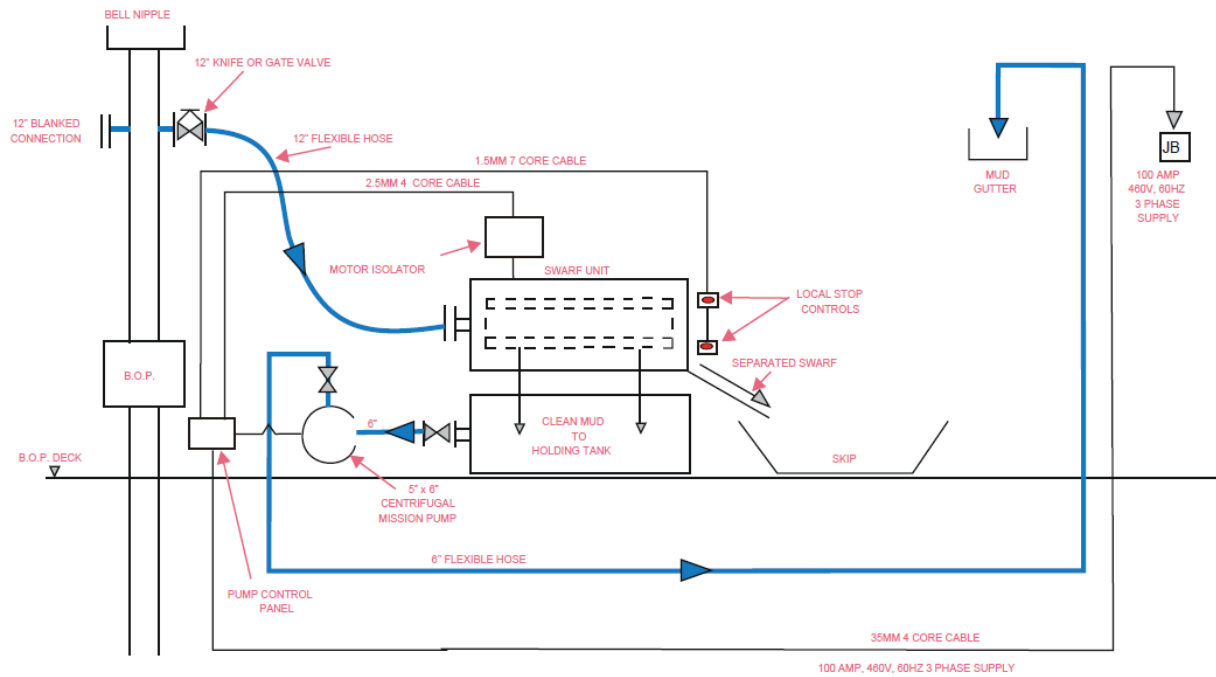
In planning for extended pilot milling or casing milling projects a Swarf Removal System should be considered. In many cases after reviewing post job analysis a substantial amount of time is shown to be spent on cleaning flowlines and shale shakers due to the sheer amount and weight of the swarf being removed from the wellbore. Also the improper ability to handle the swarf at surface can result in lower ROPs due to having to control mill so that the volume of swarf exiting the wellbore can be handled manually.

Swarf Unit advantages are as follows:

- Eliminates bottleneck of manual Swarf handling.
- Permits higher milling rates
- Safer working environment
- Simple fully automatic on-line operation
- Minimal operator intervention
- One man operator per shift
- Saves on shaker screens, manning, support costs
- Handles Flow Rates in excess of 1200GPM
- Removes in excess of 5 tons per hour of swarf.

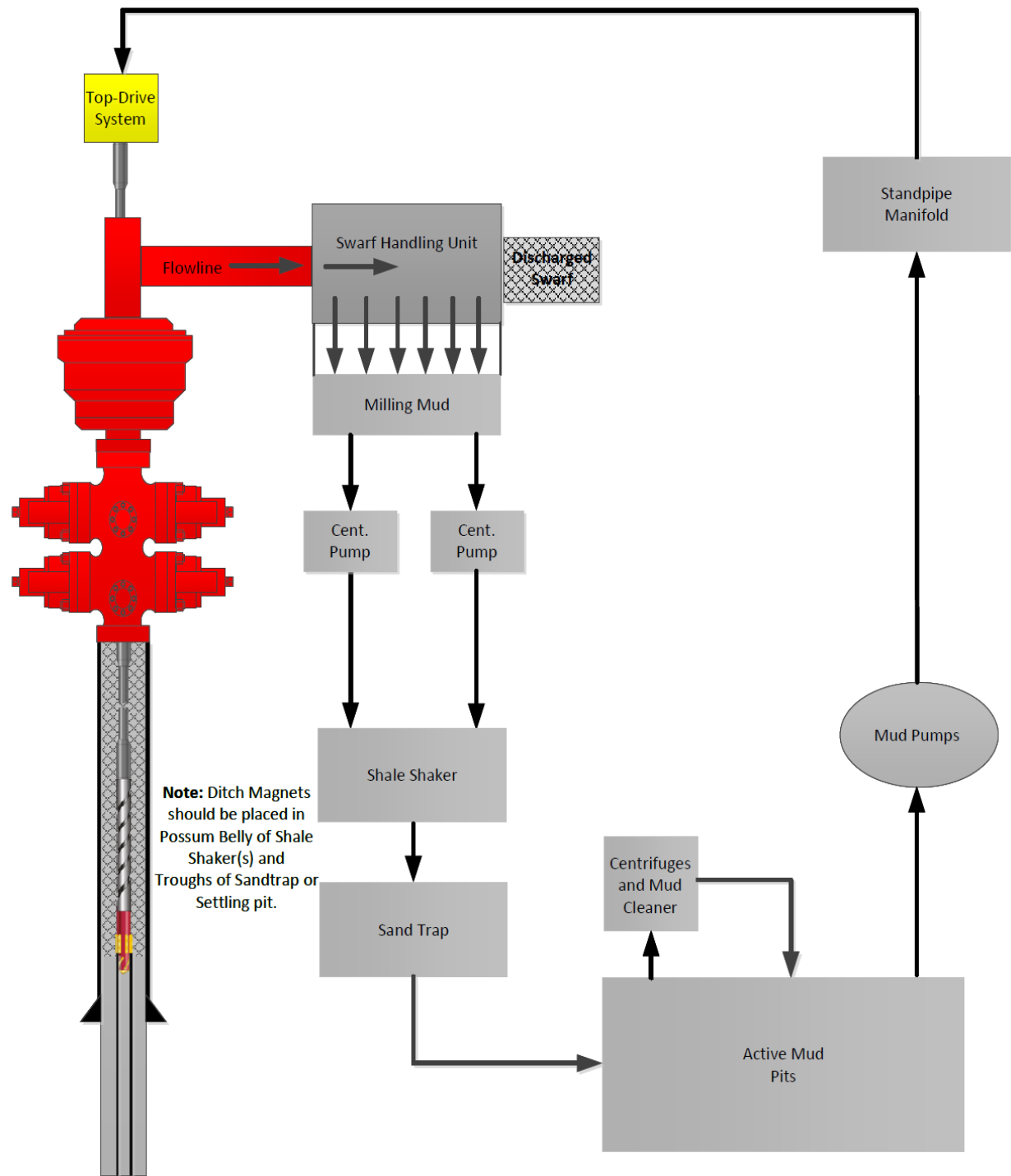
	16 of 18	Technical Work Instruction – Casing/Pilot Milling				
DOCUMENT NUMBER	CLASSIFICATION	DOCUMENT LEVEL	REVISION NUMBER	ISSUE DATE	PREPARED BY	APPROVAL
GL-INTS-OEPS-L4-716	CONTROLLED	L4	A	26 Oct 2020	Bobby Jarrett	TWI COMMITTEE

Typical Swarf Removal Unit



	17 of 18	Technical Work Instruction – Casing/Pilot Milling				
DOCUMENT NUMBER	CLASSIFICATION	DOCUMENT LEVEL	REVISION NUMBER	ISSUE DATE	PREPARED BY	APPROVAL
GL-INTS-OEPS-L4-716	CONTROLLED	L4	A	26 Oct 2020	Bobby Jarrett	TWI COMMITTEE

11.0 Basic Circulating System for Pilot/Casing Milling



	18 of 18	Technical Work Instruction – Casing/Pilot Milling				
DOCUMENT NUMBER	CLASSIFICATION	DOCUMENT LEVEL	REVISION NUMBER	ISSUE DATE	PREPARED BY	APPROVAL
GL-INTS-OEPS-L4-716	CONTROLLED	L4	A	26 Oct 2020	Bobby Jarrett	TWI COMMITTEE

12.0 References and Attachments

12.1 Reference Sources

- [Operational Control Plans](http://theportal/wcs/inv/Pages/Control%20Plan%20PL%20Documents.aspx)
<http://theportal/wcs/inv/Pages/Control%20Plan%20PL%20Documents.aspx>
- [Fishing Technology "Best Practices" Manual](#)
- [Guidelines for Effective Milling](#)

12.2 Attachments

- [PBL Sub](#)
- [Jet Stream](#)
- [OST Shock Tool](#)
- [Daily Hydraulic Drilling Jar](#)

13.0 Document Change Record

Revision Number	Effective Date	Responsible Person	Part Affected	Change Description
A	26-Oct-2020	TWI Committee	NONE	Initial release